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AGRICULTURAL MEMORANDUM NO. 962

A Comparison of Windspeeds Recorded at 10 m and 2 m

by I A Barrie, Meteorological Office, Wolverhampton

Introduction

There are about 70 climat stations in the UK recording windspeeds at a height of ten metres and around twice this number with their anemometers exposed at two metres, above ground level.

With the more generally available 2 m run-of-wind recordings, often extending back some twenty years, one is tempted to use the data at face value whenever 10 m wind records are not available.

Over the years many doubts have been cast on the representative nature of the 2 m values, with problems of over-sheltering and/or poor maintenance being paramount.

This memorandum examines the records from matching and adjacent sites to compare the windspeeds at both heights and presents guidelines on how best to interpret the 2 m windspeeds.

Exposure

To quote from the Observers Handbook (HMSO, 1969); "Exposure is a matter of the greatest importance in wind observations .....", and later, "If the site is unduly sheltered, the measurements (or estimates) of the speed (or force) may be completely unreliable .....".

Assuming that a 10 m mast is properly exposed factors to estimate the windspeed at a lower height can be calculated from a simplified form of Hellmann's formula, which reflects the logarithmic nature of the windspeed profile in the lower region of the atmosphere:

$$\frac{Uh}{U10} = 0.233 + 0.656 \log_{10} (h + 4.75)$$

where Uh = speed at height h (in metres)

U10 = speed at 10 m

leading to a correction factor of 0.78 when estimating a 2 m wind speed from a 10 m recording.

The above formula does not take into consideration the atmospheric stability and is, therefore, only strictly applicable in near neutral conditions. In this memorandum the atmospheric stability has been ignored as the data presented are, generally, averaged over a variety of different meteorological conditions and not over a time period of hours where stability would have a significant influence.

Site Details

Two sites in England have archived wind recordings over several years at both heights. The data from these sites, East Malling and Preston Wynne (Rosemaund EHF), was supplemented by data from other pairs of stations in fairly close proximity to each other: see Table 1.

Table 1. Station details of period, equipment and exposure height.

Site No.	Site	Period	Anemo. Type*	Height of Cups (m)
1a	East Malling	1978-81	Dines PTA	12
1b	" "	"	C-C	2
2a	Preston Wynne	1977-81	Mk4	13
2b	" "	"	C-C	1.8
3a	Honington	1975-80	Mk4	13
3b	Brooms Barn	"	C-C	2
4a	Elmdon	1962-80	Mk4	10
4b	Wellesbourne	"	C-C	2
5a	Watnall	1968-80	Mk4	10
5b	Sutton Bonington	"	C-C	2
6a	Gloucester	1977-80	Mk4	10
6b	Preston Wynne	"	C-C	1.8
7a	Squires Gate	1963-80	Mk4	11
7b	Kirkham	"	C-C	2
8a	Hurn	1962-80	Mk2	11
8b	Everton	"	C-C	2

*PTA Pressure Tube Anemometer
Mk4 Munro Mk4 "
C-C run-of-wind cup counter anemometer

Comparison of Mean Monthly Speeds

A simple form of analysis compares the long term mean speeds for the above pairs of recordings. This shows the general relationship between the wind speeds recorded at the two heights, without regard to any temporary variability due to wind direction, maintenance or transcription errors.

The ratios given (U_2/U_{10}, or as appropriate) should, based on Hellmann's formula, be in the order of 0.78 if the values followed the expected logarithmic relationship. One might expect that at least the average observed value should be close to 0.78.

Table 2. Ratio of $U_{z'}/U_z$ for the pairs of sites and periods in Table 1.

	Month												
Site	1	2	3	4	5	6	7	8	9	10	11	12	Mean
1	.79	.87	.81	.89	.88	.84	.86	.93	.80	.75	.77	.79	.83
2	.52	.52	.57	.53	.52	.51	.48	.44	.52	.48	.51	.51	.51
3	.52	.59	.57	.53	.53	.50	.48	.51	.52	.49	.52	.55	.53
4	.56	.57	.55	.55	.54	.53	.52	.54	.59	.54	.58	.59	.55
5	.67	.65	.70	.64	.63	.61	.61	.73	.71	.64	.66	.66	.66
6	.52	.55	.59	.64	.55	.52	.47	.48	.54	.45	.55	.54	.53
7	.42	.42	.44	.43	.37	.35	.35	.35	.33	.35	.39	.41	.38
8	.56	.57	.56	.54	.53	.50	.50	.55	.56	.55	.57	.58	.55
											Overall mean		.57

Clearly there are wide variations in the ratios of the speeds recorded at the different heights. Some of this variability could be explained by the quite different exposures when the pairs of recordings are taken from different sites. But the difference between the average value for the ratio at East Malling at 0.83 and Preston Wynne at 0.51 indicates causes other than exposure alone.

Other possible alternative explanations include*

1. The 10 m recording, being at an airfield has an open aspect and is not particularly representative of the surrounding countryside.
2. The 10 m recordings are in error due to instrument or human shortcomings.
3. The 2 m mast is over sheltered, therefore under exposed.
4. The 2 m mast is poorly maintained, therefore under-records.

*The assumption is made that the mean values of wind speed have been properly tabulated in the first instance and correctly processed thereafter.

At some of our more exposed airfield sites alternative 1 is surely true. Square Gate (Blackpool), for example, is very open to the west over the Irish Sea and relatively high recordings could be expected from this direction. This would explain some of the exceptionally low values for site 7 in Table 2. Overall though the level of maintenance is high and the analysis and siting is done by trained personnel.

The same cannot be said, regretably, for the 2 m masts. Many of them are undoubtably well cared for, as at East Malling, but all too frequently the masts are sited too near to large hedges, buildings or trees, with resultant over-sheltering. The maintenance record is also poor with the instrument often being left unattended until a particularly serious fault occurs.

The responsibility for the siting and servicing of the anemometers should be shared between the observing site and the Met. Office. The annual station inspections provide an ideal opportunity to discuss the associated problems which, if resolved, will lead to a significant improvement in the quality of the data being archived and subsequently used in calculations or analyses.

Single Site Comparisons

A more detailed analysis was done for the two sites where both sets of readings were available.

Each mean monthly value of windspeed was examined over a period of years to establish whether there was a systematic discrepancy or a variable hidden by the longer term mean monthly ratios, as shown in Table 2. These are given in figure 1 for both sites.

On examination of these time series the two most obvious features are the considerably lower ratios evident at Preston Wynne, and the occasionally very high value at both sites, indicating a discrepancy in the data. The discrepancies at Preston Wynne suggest that the 13 m wind value was inserted into the archived data-set in place of the 2 m value. Those at East Malling suggest a fault in the pressure tube anemometer recordings resulting in a decrease in the measured 12 m windspeed.

The corrections suggested in Table 3 for these values have been incorporated in Table 2.

Table 3. Suggested values for suspect monthly mean wind speeds.

		Archived Value	Suggested Correction
Preston Wynne	March 1981 (2 m)	8.8 kt	4.8 kt
	October 1981 (2 m)	6.8 kt	3.4 kt
East Malling	June 1980 (12 m)	4.5 kt	4.8 kt
	July "	4.4	4.8
	Aug. "	3.7	4.4
	Sept. "	2.9	4.4
	Oct. "	3.8	5.2
	Nov. "	6.5	7.8

To further isolate the cause of the error, two fairly representative months were chosen and the daily mean wind speeds plotted on a scatter diagram, see figure 2. A strict comparison should not be made on a daily basis as the period of the daily records are not exactly the same; 09-09 GMT for the 2 m and 00-23 GMT for the 10 m winds. Problems associated with non-neutral atmospheric conditions would also be apparent.

Nevertheless the conclusion evident in figure 2 is unavoidable. The values from East Malling are consistant with what theory would suggest. Those from Preston Wynne indicate a start-up speed for the cup-counter of between 4 and 5 knots; a sure sign of worn or dirty bearings, given that the exposure of the instruments there has been seen to be good.

Conclusions

1. There are many poorly exposed and/or badly maintained 2 m cup-counter anemometers: a purge should be initiated to up-grade the 2 m network.
2. Data held in the Met. Office archive for both 10 m and 2 m recordings have some suspicious values.
3. No universal factor emerges for correcting a 2 m wind speed to give a fairer reflection of the "true value" but in most instances a value of around 1.37 would not be unreasonable.

Annex A of this memorandum gives some guidelines which climat station

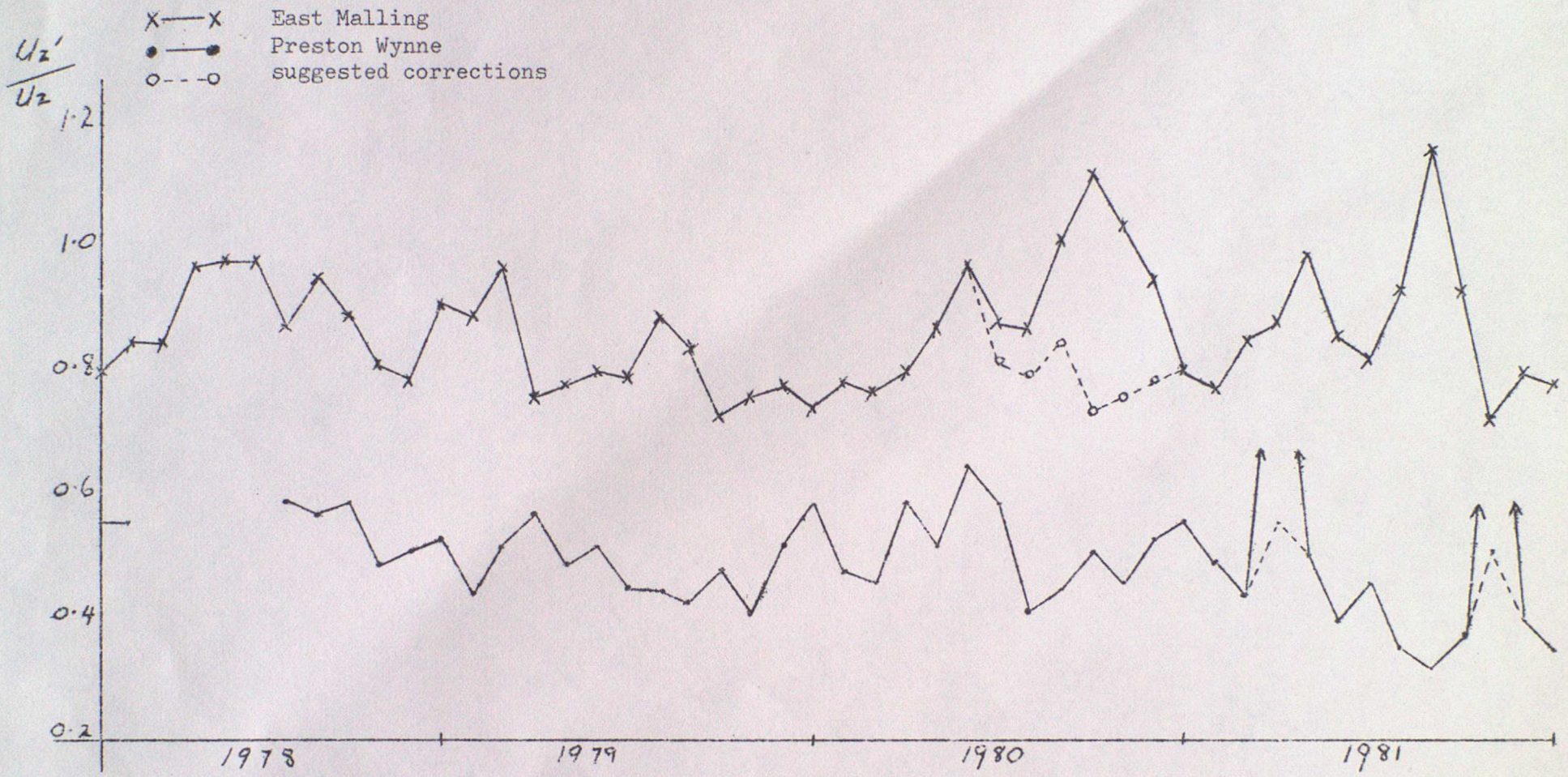
observers should be encouraged to follow on how to perform simple maintenance of their anemometer. (Copied from the "Handbook of Meteorological Instruments Part I", pages 206-208). The problems of exposure should be tackled during the site inspections.

Met Unit,
MAFF
Wolverhampton

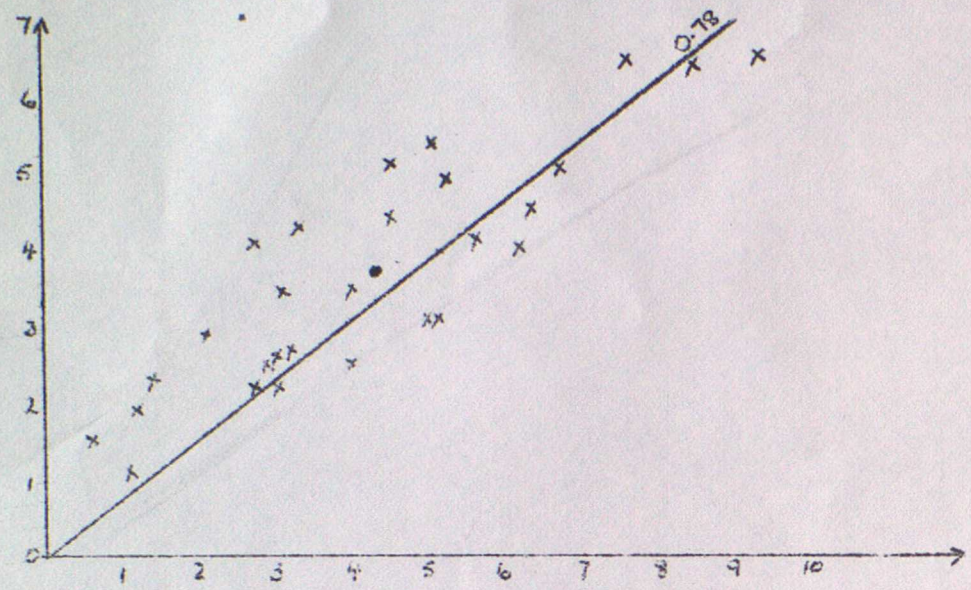
October 1982

Monthly Values for $^{U2}/_{U12}$ (or as appropriate), 1978-81

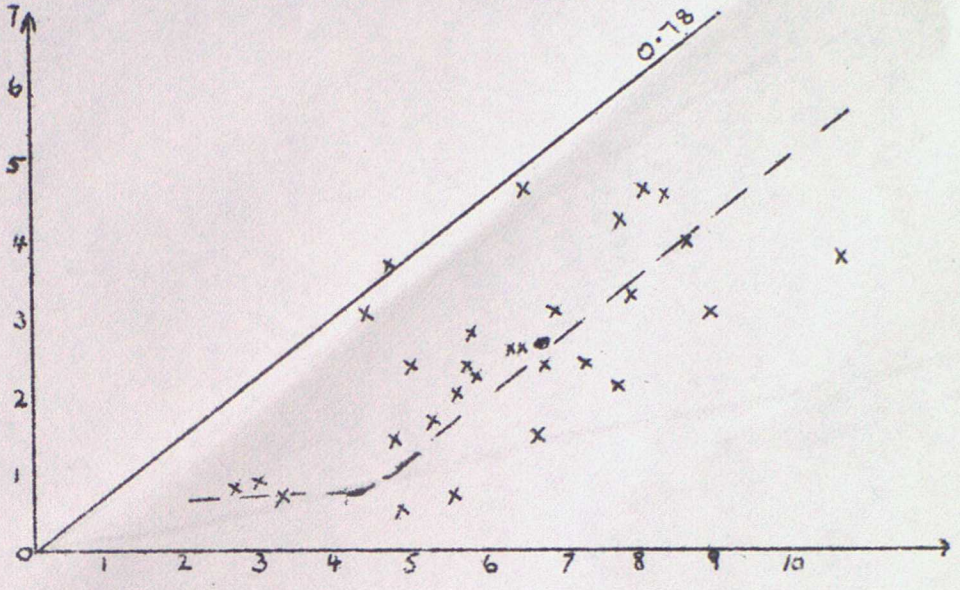
Fig. 1



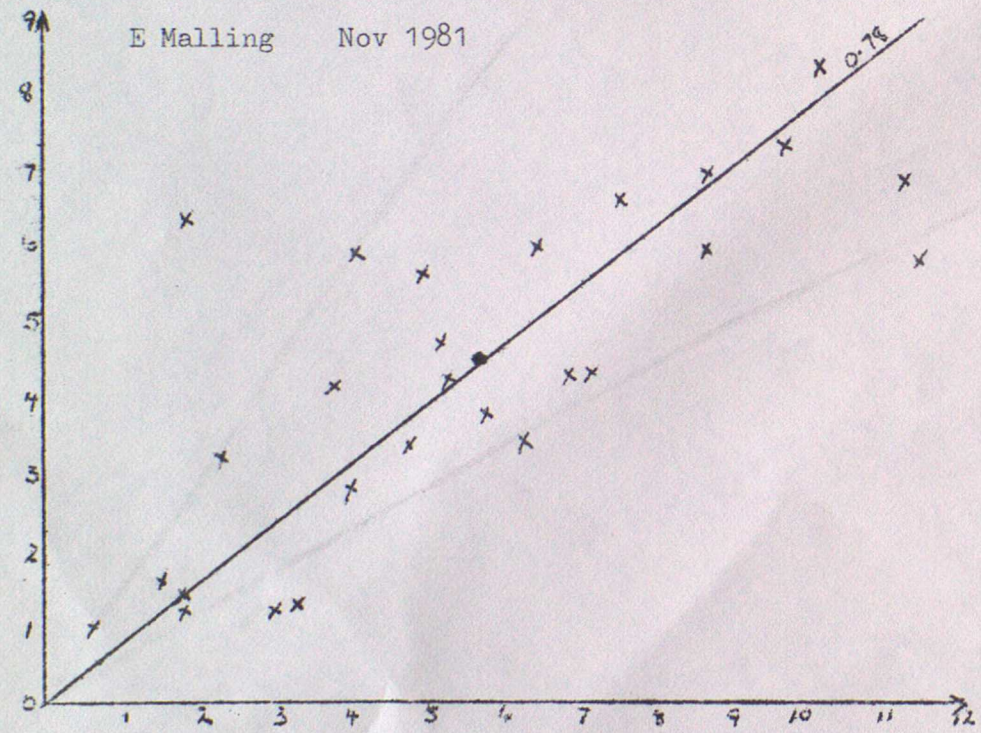
E Malling July 1978 ● = monthly mean



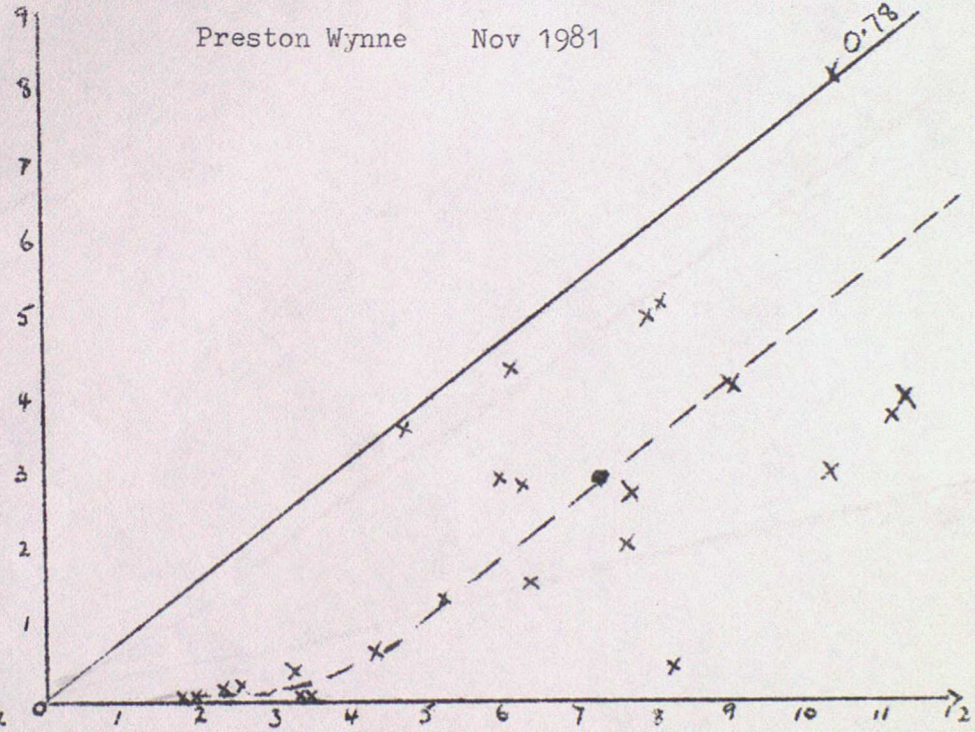
Preston Wynne July 1980 FIG 2



E Malling Nov 1981



Preston Wynne Nov 1981



CUP COUNTER ANEMOMETER Mk II

ANNEX A

5.3.1

Maintenance and repair.—The instrument should be inspected and cleaned at intervals of three months according to the following routine :

(i) Place the instrument on a clear bench, remove the cap nut and lift the cup wheel off the spindle, taking care not to lose the washer which lies between the cap nut and the cup wheel casting. If the cup wheel is stuck to the spindle, loosen the cap nut but do not remove it ; support the cup wheel in one hand and strike the cap nut smartly with a mallet or screw-driver handle.

(ii) Clean the cup wheel thoroughly, checking that the cup retaining nuts are tight and that the cups are not loose on their arms.

(iii) Clean thoroughly the exterior of the counter box and the spindle tube.

(iv) Undo the six screws which hold the counter box to its lid and lift the lid and spindle assembly off the box ; the centre screw on the dial side is prevented from coming completely out by the dial window retaining frame so that the lid must be lifted off as this screw is undone.

(v) Clean the transparent dial panel, removing its frame if it is dirty inside ; do not scratch the panel (it is made of perspex, not glass). Clean the inside of the box, and dry it thoroughly if damp. Grease the screwed socket on the under side of the base.

(vi) Remove the grub screw which holds in the brass cap above the upper spindle bearing and take out the cap ; if obstinate the projecting rim of the cap can be held in a vice, using lead or fibre jaws, and the lid assembly twisted.

(vii) Remove the lower bearing end cap in the same way ; the lower steel race of the thrust bearing will come out with this cap, followed by the brass ball cage. The spindle can now be withdrawn, complete with worm and thrust-bearing top steel race, downwards.

(viii) Tap out the upper ball-bearing upwards, and clean both ball-bearings by immersion in petrol until all oil, grease or dirt is removed. The upper bearing is of the single-row rigid journal type, $\frac{1}{4}$-in. bore by $\frac{3}{4}$-in. outside diameter ; the lower is a flat-seated thrust-bearing $\frac{1}{4}$-in. bore by $\frac{3}{8}\frac{1}{2}$-in. outside diameter by $\frac{1}{4}$ in. thick.

(ix) The upper bearing should be replaced if it is in a very bad condition, but if it revolves freely after cleaning it can be used again.

(x) Clean the spindle and worm, and lubricate the latter with a little thin oil. If the top bearing shows no sign of rust, lubricate it after cleaning with low-temperature grease.

(xi) Clean the counter wheels, and check that they are free on their spindles. These wheels and their pinions are purposely made an easy fit on their spindles and should run dry. If they are not free, remove the large wheel spindle by loosening the set screw which retains it and pushing out endways ; take off the wheels, clean their central holes and the spindle, and replace.

(xii) Reassemble in the following order :—top bearing (from above), spindle (from below), thrust-bearing ball cage, lower cap, lower cap grub screw, upper cap, upper cap grub screw.

(xiii) Replace the lid on the box and tighten up the six retaining screws. Reassemble the cup wheel on the spindle, replace the washer, and replace and tighten the cap nut. The anemometer can then be remounted on its support.

Accuracy.—The general accuracy of the cup anemometer has already been discussed. The cup counter Mk II has errors of less than 1 kt. at all normal wind speeds above about 5 kt. It normally begins to rotate at wind speeds of the order of $1\frac{1}{2}$–2 kt., and between 2 and 5 kt. its indications depend to a large extent on the bearing friction and the state in which the instrument is maintained. If the friction seems excessive, the anemometer should be tested by being placed on a horizontal surface indoors in a place free from draughts and the cups rotated at a rate of 1 rev./sec. in the same direction as the wind would turn them. The time taken for the cups to come to rest after being released at this rate should exceed 60 sec.

5.3.2. Cup counter anemometer Mk I

The Mk I instrument (Stores Ref., Met. 511), now obsolescent, differs from the Mk II in having a longer spindle and three beaded-edge hemispherical cups in place of the conical cups. Various types of spindle-bearing systems are employed. The method of operation is similar to that of the Mk II, and the anemometers should be cleaned and inspected at regular intervals (about every three months). The instructions given for the Mk II instrument can be used as a general guide but the details will be different.